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Global and Korean Peninsula Climate Changes and Their Environmental Changes

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Abstract

The modern foraminiferal distribution patterns and species diversity in surrounding seas of Korea are controlled by winter monsoon and characteristics of water masses. Abrupt climate change, Younger Dryas cold episode" is identified in Korea. The Younger Dryas is characterized by local extinctions of foraminifera. Several record-breaking climate phenomena observed in Korea, especially September, 2007.

1. Introduction

Currently we are living on climatic transitional period, for example, climatic mode from A to B. Three types of climatic change patterns are known from paleoclimatology record. That is, gradual changes, step-wise changes, and abrupt changes. Abrupt climate changes are defined by temperature changes greater or less than 2 ℃ from previous period. Based on IPCC (2007) report, the atmospheric temperature will rise maximum approximately 6.4℃ until 2100. This 6℃ rise of temperature is unusual.

Futhermore, out future (from now to at least year 2100) will be completely different from now. It is very important to understand the paleoclimatic history in order to understand the modern and future climate. In this study paleoclimatology including modern climatology are reviewed.

2. Materials and methods

Several previous paleoclimates (including modern climate changes) and their related environmental changes are reviewed. Particularly, controlling factors of modern foraminifera and species diversity are discussed. Paleoclimatic history of the East Sea and modern atmospheric temperature changes are also discussed.

3. Results and discussion

It is essential to understand the paleoclimatology in order to understand the modern and future climate changes. Paleoclimatology during the past a few hundred million years is briefly reviewed (Shin *et al.*, 2005). Global sea surface temperature varied within 20℃ and bottom water temperature varied within 15℃ during the past 200 million years. Particularly, global seasurface temperature varied within 1℃ during the past 10,000 years, and varied within 0.5℃ during the past 1,000 years. Carbon dioxide concentrations varied between 180 and 3,000 ppm during the past 200 million years. Current value of carbon dioxide concentration is 390ppm and this value never happened at least during the past 750,000 years. Current value of methane concentration is 1,850 ppb, and this value never reached at least during the past 20 million years. Concerning this, we are currently living on very unusual climatic conditions.

To understand the paleoclimatic history of surrounding Korean seas, it is very important to understand the controlling factors of modern foraminifera. To understand the controlling factor of foraminifera, a time series sediment trap was deployed in the interior of the East Sea. Total foraminifera flux varied from 3 to 8,200 specimens/m^2/day, with major peaks during late fall and winter, and a minor peak during spring (Park and Shin, 1998). Foraminiferal assemblages were dominated by both right- and left-coiled *Neogloboquadrina pachyderma*, *N. dutertrei,* and *Globigerina bulloides*, and their fluxes varied seasonally. The highest flux of both right- and left-coiled *N. pachyderma* throughout all seasons indicates that the East Sea was dominated by the cold Subarctic water mass. The influx from the cold North Korean Current was stronger than that of the warm Tsushima Current in the spring. This cold water influx is evidenced by the highest flux of left coiled *N. pachyderma* and *Globigerinoides bulloides*, and the absence of N. *dutertrei.*

In the East Sea, the highest number of planktonic foraminifera occurs in November. The onset of the winter monsoon (late October-November) is responsible for the planktonic foraminifera flux peak during November, and species compositions.

The controlling factors for species diversity indices [S, H(S), E] of planktonic foraminifera are investigated from the interior of the East Sea (Shin, Park, and Yi, 1998). Conventionally, higher species richness (S) and Shannon-Wiener index [H(S)] occur in warm surface water. In the East Sea, higher species richness (S) shows a moderate positive correlation ($r=0.69$; $p<0.02$) with right-coiled *N. pachyderma* rather than surface water temperature. This indicates that the warm Tsushima current carried rare species in East Sea. However, H(S) values show moderate negative correlation with the monthly averaged surface water temperature ($r=0.73$; $p<0.01$), positive correlation with the relative abundances of *Globigerina bulloides* ($r=0.71$; $p<0.01$), and strong negative correlation with the relative abundances of *N. pachyderma* (both right-coiled plus left-coiled) ($r=-0.91$; $p<0.01$). These observations suggest that higher species diversity [H(S)] occurs in relatively cold surface water temperatures. This is due to the unique nature of the study site where the North Korean Cold Current and the East Sea Warm Current (Tsushima Warm Current) converge together.

The moderate negative correlation of E values with the relative abundance of right-coiled *N. pachyderma* ($r=0.70$; $p<0.01$) indicates that higher E values occur in cold surface water. E values also show poor negative correlation with salinity values ($r=0.55$; $p<0.05$) suggests that even distribution of planktonic foraminifera partly controlled by salinity of surface water.

The isotopic and micropaleontology records from the piston core of the East Sea, covering the last deglaciation, is dated by C-14 Accelerator Mass Spectrometry (Park, Shin, and Han, 1997). The result shows a definite cooling event of the Younger Dryas. A meltwater spike is shown at slightly older than 11.7 ka. Dramatic paleoceanographic (surface water temperature and salinity change) shifts occurred within a very short period which corresponded to the core interval of 10cm. This 10cm core interval is equivalent to approximately 1,000-year period. A brief cold event is recognized between 11.2 and 8ka from the East Sea core. This oceanic event in the East Sea of Korea is the Younger Dryas cold epoch.

These abrupt climate change influenced on the East Sea ecosystem. Environmental changes caused by the abrupt climatic change are one of the important issues in the scientific community. In the East Sea, changes in circulation and bottom water conditions occurred during the Younger Dryas cold episode. Especially, climatic transition from meltwater spike to the Younger Dryas cold episode is characterized by significant shifts of oxygen isotope values, the coiling ratios of *Neogloboquadrina pachyderma*, and the planktonic foraminifers abundances (Shin *et al.*, 2003).

The impact of abrupt climate change on the ecosystem is very significant. In the East Sea, the calcium carbonate secreting organism (foraminifers) is replaced by silicon dioxide secreting organism (diatom, radiolarian) after the abrupt and severe cold climatic event. Based on the Doctrine of Uniformitarianism, at least climate change for the next 100 years would be severely influence on the marine ecosystem.

This Younger Dryas cold episode is a global phenomena (Broecker *et al.,* 1989; Broecker, 1990; Flower and Kennett, 1990). In Norwegian Sea, most dramatic drop in marine organic carbon and biogenic carbonate properties occurred during Younger Dryas, and this caused abrupt changes in biogenic sedimentation (Knies *et al.,* 2003).

The mean, maximum, and minimum temperature records from 60 meteorological stations for the period 1973-2006 are analyzed. All thermometers were located at 1.5m above ground level. The mean, average values of maximum and minimum temperature show upwards trend. The mean temperature of 2000s (average of 2001-2006) was increased 0.6℃ compare to that of the 1970s (1973-1980).

This September is characterized by greatest amount of precipitation and cloud, including the greatest number of rainy days and the highest humidity since 1973. Furthermore, this September is recorded as the lowest diurnal temperature range and sunshine duration since 1973. These record-breaking phenomena occurs mainly during the climatic transitional period.

Conclusions

In East Sea, upwelling, characteristics of water masses and winter monsoon control the occurrence, species compositions and species diversity of planktonic foraminifera. Particularly, greatest number of planktonic foraminifera occurs during winter monsoon. Many record-breaking climatic record occurred this year (September). This is due to the greater climate variability during the climatic transitional period and global warming.

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